5.16.41 DETERMINATION OF DENSITY AND MOISTURE CONTENT OF PORTLAND CEMENT TREATED BASES, AGGREGATE BASES AND AGGREGATE SHOULDERS BY NUCLEAR METHOD (Kansas Test Method KT-41)

a. SCOPE

This method of test covers the procedure for calibrating nuclear gauge and determining density and moisture in Portland Cement treated bases, aggregate bases and aggregate shoulders. **Gauge calibration shall follow 5.21.02 INDEPENDENT ASSURANCE REPLICATE (ASR) CHECK FOR NUCLEAR DENSITY GAUGES.** KDOT gauges shall be calibrated at the Materials and Research Center. KT-41 reflects testing procedures found in AASHTO T 271.

The equipment utilizes radioactive materials which may be hazardous to the health of users unless proper precautions are taken. (For KDOT field personnel only: Refer to Standard Operating Manual No. 1.13.2.)

b. REFERENCED DOCUMENTS

b.1. KT-11; Moisture Tests – Constant Mass Method

b.2. KT-13; Field Density Tests of Soils, Treated Base Courses, and Water Bound Base Courses

b.3. KT-32; Method of Test for Density of Compacted Asphalt Mixtures by Nuclear Method

b.4. KT-43; Moisture Content of Asphalt Mixtures or Mineral Aggregates - Microwave Oven Method

b.5. AASHTO T 271; Density of Plastic and Hardened Portland Cement Concrete in Place by Nuclear Methods

c. APPARATUS

c.1. Nuclear moisture/density gauge with supporting equipment including reference standard, survey meter and instructional material.

c.2. KDOT Validator: Device to establish a field correction factor for the nuclear gauge. Each Validator has a certified block density.

c.3. Balance readable to 0.01 lb (5 g) and sensitive to 0.005 lb (1 g).

c.4. A supply of minus No. 30 (600 μm) sand with no more than 20% represented by minus No. 100 (150 μm).

c.5. Brush for cleaning up the fine sand.

c.6. Shelter to protect the balance from wind currents and the sample from exposure to the sun or wind.

c.7. Oven capable of maintaining a constant temperature of approximately 230°F (110°C). If available, a microwave oven as described in KT-43 may be used.

c.8. Miscellaneous equipment including standard drying pans, trowel, large spoon, hammer and square point shovel.

d. SAFETY

The nuclear gauge shall be operated in accordance with all KDHE safety rules and regulations.

e. NUCLEAR GAUGE WARM-UP AND CHECK

The nuclear gauge shall be turned on for warm-up and checked according to the manufacturer's instructions.

f. TEST SITE SELECTION AND PREPARATION

Test site shall be selected as outlined in **KT-32 d.** A leveling sand may be needed.

g. VALIDATOR CORRECTION FACTOR

g.1. Use the KDOT Validator to determine the field correction factor for density in the following manner:

g.1.a. Place the gauge on the Validator at the depth to be used on the project.

g.1.b. Take three one-minute readings.

g.1.c. Determine the average difference (field density correction factor) using **j.1.**

g.1.d. Use this correction factor to determine the final density reading for each test site.

h. PERCENT MOISTURE CORRECTION FACTOR

h.1. Use KT-11, Constant Mass Method, to determine the percent moisture correction factor.

h.2. Dry the material removed from the test hole to a constant weight at approximately 230°F (110°C). The material shall be dried the same day it is cored. Record the dry weight and calculate the percent moisture.

h.3. Conduct a minimum of seven tests. Compute the correction factor for each test. The sample standard deviation (*s*) for the percent moisture content correction factors must be less than 1%. If the above criteria are met, use the average correction factor computed. If the s criteria are not met, start over again with seven new tests.

i. TEST PROCEDURE

i.1. Location of the test site should be on a random basis. Any of several methods may be used; however, the use of a set of Random Number Tables is recommended. Regardless of the method of random selection chosen, it shall satisfy the requirement that any area of the surface shall have an equal chance of being sampled. Sampling shall not be conducted on sites closer than 1.0 ft (0.3 m) to an unconfined edge or vertical surface such as a raised edge of curb and gutter, etc. When the randomized selection method indicates a site within 1 ft (0.3 m) of an exposed edge or vertical surface, it is permissible to move the gauge transversely to clear the 1 ft (0.3 m) restriction. It is also permissible to determine an alternate location using the table again.

i.2. Since the measured values of density are affected by the surface conformation of the material immediately beneath the gauge, a flat surface should be tested for best results, both during calibration and density testing. If the mix has a coarse surface, it is likely that the results will vary widely. Calibration and testing should be done with a leveling sand immediately beneath the gauge. Spread thinly a sufficient amount of minus No. 30 (600 μm) sand on the test site and smooth with the metal plate or a straight edge to obtain a suitable surface with a minimum amount of the sand.

i.3. After the site selection has been made, a vertical hole is made 2 in (50 mm) deeper than the thickness of the material with the rod and plate provided with the gauge. If the thickness of the material exceeds the depth capability of the gauge, then a hole is made 2 in (50 mm) deeper than the gauge's maximum depth. The same hole depth used for calibration is to be used for normal testing. Set the probe to maximum depth or at a depth equal to the plan thickness, whichever is less. Wet density and moisture readings can now be taken using 3 one-minute counts. The set of one-minute counts must meet the criteria detailed in **KT-32 h.1.**

j. CALCULATION

j.1. Compute Field Density Correction Factor.

Individual Correction Factor = Validator – Nuclear Gauge

$$\text{Avg. Correction Factor} = \frac{\sum 3\, Individual\, Correction\, Factors}{3}$$

$$WD = WD_i + \text{Avg. Correction Factor}$$

Where: WD_i = initial reading at test site
Validator = certified block density

j.2. Compute Percent Moisture Content Correction Factor.

$U_i = (w - X)$

Where: w = moisture content, percent (see **KT-11 e.1.** for determination of w)
X = Nuclear Gauge moisture content, percent
Ui = Individual difference between w and X

Average percent moisture content correction factor (U).

$$U = \frac{\sum U_i}{n}$$

j.3. Sample standard deviation (s) (see **KT-32 g.6.a.1.** for more detail):

$$s = \sqrt{\frac{\sum (d_i - d_b)^2}{n - 1}}$$

Where: d_i = Individual difference (U_i)
d_b = Average difference (U)

j.4. Corrected Percent Moisture Content, (%M)

$\%M = (X + U)$

j.5. Dry Density, lb/ft^3 (kg/m^3), (DD)

$$DD = \frac{WD}{\left(1 + \frac{\%M}{100}\right)}$$

Where: WD = Nuclear Gauge Wet Density, lb/ft^3 (kg/m^3)